

Navigating future uncertainty in marine protected area governance: Lessons from the Scottish MPA network

Charlotte Rachael Hopkins^{a,*}, David Mark Bailey^a, Tavis Potts^b

^a Institute of Biodiversity, Animal Health and Comparative Medicine, University of Glasgow, Glasgow, G12 8QQ, UK

^b Department of Geography and Environment, University of Aberdeen, AB24 3UF, UK

Abstract

As international pressure for marine protection has increased, Scotland has increased spatial protection through the development of a Marine Protected Area (MPA) network. Few MPA networks to date have included specific considerations of climate change in the design, monitoring or management of the network. The Scottish MPA network followed a feature-led approach to identify a series of MPAs across the Scottish marine area and incorporated the diverse views of many different stakeholders. This feature led approach has led to wide ranging opinions and understandings regarding the success of the MPA network. Translating ideas of success into a policy approach whilst also considering how climate change may affect these ideas of success is a complex challenge. This paper presents the results of a Delphi process that aimed to facilitate clear communication between academics, policy makers and stakeholders in order to identify specific climate change considerations applicable to the Scottish MPA network. This study engaged a group of academic and non-academic stakeholders to discuss potential options that could be translated into an operational process for management of the MPA network. The results of Delphi process discussion are presented with the output of a management matrix tool, which could aid in future decisions for MPA management under scenarios of climate change.

Key Words: climate change, Delphi technique, MPA management, marine protected area network, Scotland

27 1. Introduction

28 Marine ecosystems are facing a diverse range of threats, including climate change,
29 prompting international efforts to safeguard marine biodiversity through the use of spatial
30 management measures (Allison et al., 1998; Lubchenco et al., 2003; Chuenpagdee et al.,
31 2013). Marine Protected Areas (MPAs) have been implemented as a conservation tool
32 throughout the world, but their usefulness and effectiveness is strongly challenged by
33 climate change (Harley et al., 2006; Andrello et al., 2015). Whilst MPAs cannot explicitly
34 protect against climate change related disturbances (e.g. ocean acidification), MPAs can
35 assist in sustaining biodiversity and ecosystem processes at regional and local scales (Levy
36 and Ban, 2013). The reduction of other anthropogenic threats (e.g. overfishing) can
37 minimise the synergistic impact of other stressors which may exacerbate detrimental
38 changes to ecosystem health (Harley and Rogers-Bennett, 2004; Harley et al., 2006; Levy
39 and Ban, 2013). The reduction of additional stressors could also contribute to increased
40 ecosystem resilience in the face of climatic stress (see Bernhardt and Leslie, 2013).
41 However, few MPA programmes have directly considered climate change in the design,
42 management or monitoring of an MPA network (Hopkins et al., 2016a). Considering
43 elements of design, management and monitoring that could enable an MPA network to
44 perform effectively under scenarios of climate change, could also improve networks more
45 generally.

46 Under international obligations, EU, UK and national targets (e.g. CBD, OSPAR), Scotland has
47 developed an MPA network intended to protect marine biodiversity and contribute to the
48 vision of a clean, healthy and productive marine environment (Scottish Government,
49 2011a). The implementation of the Scottish MPA network has been a complex process
50 requiring the consideration of stakeholder values and perceptions, scientific evidence and
51 political factors (Hopkins et al., 2016b). There is a need to facilitate clear communication
52 between academics, policy makers and stakeholders to progress MPA policy delivery and
53 ensure decisions are jointly formed and therefore acceptable to multiple parties (Pollnac et
54 al., 2010). The Scottish Nature Conservation MPA network consists of 30 MPAs designated
55 in 2014: 17 MPAs under the Marine (Scotland) Act 2010 in Scottish territorial waters and 13
56 MPAs under the Marine and Coastal Access Act 2009. Scottish Natural Heritage (SNH) and

the Joint Nature Conservation Committee (JNCC) submitted formal advice to parliament following a series of stakeholder workshops.

The Scottish MPA network (including other types of protected area designation) covers approximately 20% of the Scottish sea area. The Scottish MPA network is intended to contribute to an OSPAR ecologically coherent network and is part of the Scottish Government's three pillar approach to conservation, which includes spatial protection, wider seas measures and species-specific protection and management measures (Scottish Government, 2011a). Together, the three-pillar approach is intended to contribute to the achievement of Good Environmental Status (GES) under the Marine Strategy Framework Directive (MSFD). Therefore, it is important to assess the contribution that the MPA network makes towards protecting marine biodiversity and the delivery of GES. Furthermore, with increasing pressure from climate change on marine biodiversity, an effective MPA network will be crucial in providing climate change resilience. We define resilience here as the ability of an ecosystem to experience disturbance without substantial biological change (Holling, 1973), a change that could result in an alternative state and loss of ecosystem function (Côté and Darling, 2010).

The Scottish MPA network was developed using a feature-based approach to site selection, whereby MPA sites were selected based on the “locations of habitats or species which are important, rare, threatened and/or representative of the range of features in the UK marine area” (Scottish Government, 2011b) termed Priority Marine Features (PMFs) (see Howson et al., 2012). It will be important to assess whether such a feature led approach is effective for selecting MPA sites that will remain resilient under climate change scenarios. Each Scottish MPA also has a Conservation Objective of either “conserve” or “recover” tying MPA management measures to the feature for which each site was designated. These objectives are vague and therefore difficult to measure under climate change scenarios where it may become unfeasible to achieve such an objective (Cliquet et al., 2009).

The aim of this study was to facilitate the identification of high level management options for Scottish MPA network in the context of potential climate change scenarios prior to the development of site specific management options. There are few examples of high level

MPA decision making, for example, under what circumstances should a new MPA be designated, or an MPA that is no longer effective or successful, de-designated. This study aimed to explore these options in the context of climate change, answering the following research questions:

Are there differences in the perceptions of MPA success between different stakeholder groups?

How can we effectively protect marine ecosystems under climate change scenarios?

What are feasible options for including climate change specific management and monitoring strategies?

2. Materials and methods

A Delphi method was devised in this study to elicit perceptions and options for climate change management scenarios. The Delphi method is becoming more frequently applied to conservation and biodiversity management issues due to their complex nature, involving a range of stakeholders and trade-offs (Hess and King, 2002; O'Neill et al., 2008; Gobbi et al., 2012). The Delphi method is a flexible methodology suitable for complex policy problems, particularly where there is significant uncertainty, lack of historical precedent and especially in situations where information is limited or conflicting (Mukherjee et al., 2015). Questions are posed and responses to those questions exchanged usually anonymously with other participations via a process facilitator and is an effective way for a group to deal with a complex issue either reaching consensus or identifying convergence of opinion (Linstone and Turoff, 2002; Hsu and Sandford, 2007). The benefit of the reflective deliberation of the Delphi method may also be the development of more creative solutions by groups of people (Reed, 2008). The Delphi method employed here did not seek consensus, seeking instead an improvement in understanding and clarification of the issue, therefore sharing similarities with Policy Delphi. As Rowe and Wright (2011) suggest, the most interesting and important issues often emerge where consensus is not evident.

MPA processes involve a complex range of stakeholders from various economic, social and environmental interest groups. As such, the panel was carefully selected to apply their knowledge and experience to the study issue and to reflect the diversity of stakeholders involved in the MPA process. Following Glass et al. (2013) a stakeholder map was created to identify a matrix of organisations and stakeholder interest groups related to the Scottish MPA process. Potential participants were selected if they met one or more of the following criteria: active role in the Scottish MPA process, relevant experience in other UK MPA processes, member of a representative body, and academically relevant research to MPAs and/or marine climate change. The size of the panel is not a critical feature of the Delphi method as participants are purposefully rather than randomly selected and reliable results can be obtained by choosing participants using strict inclusion criteria (Akins et al., 2005).

2.1. Progression through rounds

The Delphi study began in January 2014 and consisted of two emailed questionnaires and a final focus group round that concluded the participant input process in September 2014. The focus group provided the participants with an opportunity for face to face interaction, encouraging motivation to remain engaged in the process. The participants had an adequate history of communication through the Scottish MPA process stakeholder workshops. Additionally, the use of the focus group further complemented the Delphi technique by emphasising the synergy of a group for producing ideas over and above individual contributions (Krueger and Casey, 2009). Results presented in this paper reflect final outcomes from the Delphi method, following the three rounds (Fig. 1.). Round One and Two identified potential management options and discussed the feasibility of these options. Recognising the feature-based approach to designation of the Scottish MPAs, the participants of the focus group were presented with a series of feature-based scenarios whereby the abundance or presence of a feature changed, to explore which possible management options were available and under which circumstances these were acceptable and feasible. The scenarios focused on the high level management options suggested by participants in previous rounds, rather than specific management relating to activities (e.g. types of gear restriction).

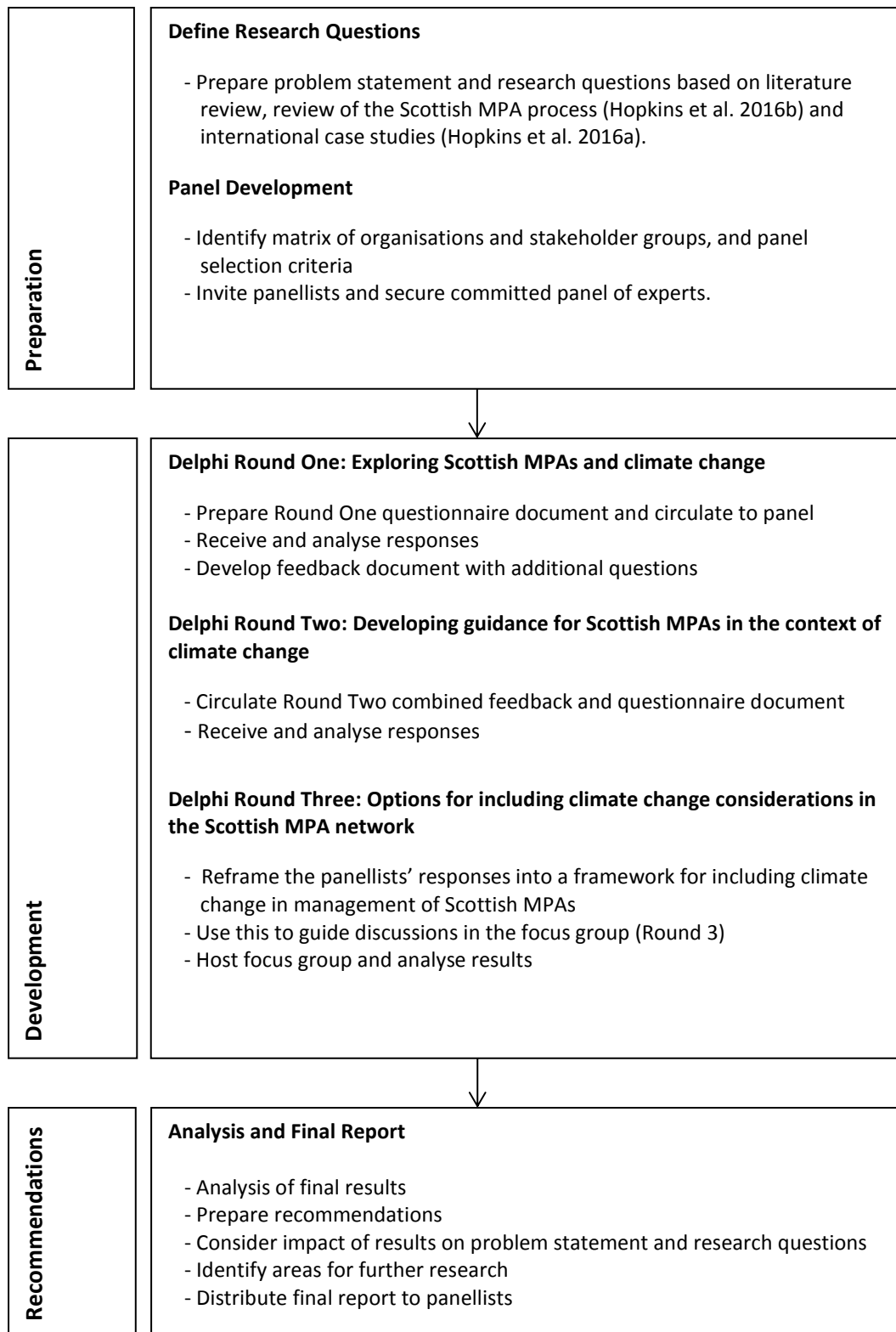


Figure 1. Overview of the Delphi process to identify management options under climate change scenarios for the Scottish MPA network. (Adapted from Lemieux and Scott (2011)).

143

144 2.2. Composition of the panel

145 Upon acceptance respondents from similar organisations nominated one person to speak
146 on behalf of the interest group and this person became the point of contact (Participants 1,
147 2 and 10). Reasons given for the collective input included the already heavy investment of
148 relevant organisations involved in the on-going MPA designation process and reshuffling of
149 employees within the relevant organisations to different policy areas. Six participants
150 completed the Round One questionnaire and four participants responded to the Round Two
151 questionnaire (Participants 1 and 8 did not complete). Whilst, this resulted in a low panel
152 number for Round Two and a loss of two perspectives (policy maker and
153 practitioner/professional), the information provided by the remaining four panellists was
154 detailed and illustrated in-depth thinking concerning the feedback (from Round One) and
155 resultant questions. Additionally, there was some overlap in the remaining participants with
156 the non-respondents in terms of experience and background (i.e. a practitioner/professional
157 and policy maker responded to Round Two). To counter-act the lower response rate of
158 Round Two further action was taken: i) renewed efforts were made to contact the
159 participants to encourage them to respond to the questionnaire and subsequent round; ii)
160 additional potential participants from the stakeholder map having experience and
161 knowledge in the research topic were invited to participate in the Delphi focus group.
162 Subsequently, Participant 8 confirmed their acceptance of the invitation to attend the focus
163 group with an additional four participants. The focus group was attended by ten participants
164 (seven of whom had provided input into the preceding questionnaires (Table 1).

165

166 Table 1. Summary of participant characteristics and identification method.

Sub-Focus Group	Participant Number ¹	Organisation	(Group)	Identification Method
-	1*	Marine Scotland	Policy Makers and decision makers	Stakeholder Workshop Referral; reputation
-	2**	Scottish Environment Link	Representative Body; NGO	Stakeholder Workshop; reputation
1	3	Royal Society for the Protection of Birds (RSPB)	Representative Body; NGO	Stakeholder Workshop; reputation
1	4	Scottish Fishermen's Federation (SFF)	Representative Body	Stakeholder Workshop; referral
1	5†	Visit Scotland		Referral
1	6	Marine Conservation Society (MCS)	Representative Body; NGO	Stakeholder Workshop; reputation
1	7†	Sniffer (Registered charity)	Practitioner and Professional	Referral
2	8***	British Sub Aqua Club (BSAC), Academic	Practitioner and Professional	Referral; reputation
2	9	RSPB	Representative Body; NGO	Stakeholder Workshop; reputation
2	10	Scottish Natural Heritage (SNH)	Policy Makers and decision makers	Grey literature; Referral; reputation
2	11†	Academic	Practitioner and Professional	Referral; academic publications
2	12	Academic	Practitioner and Professional	Referral; academic publications

*Participant completed Round 1 questionnaire but did not attend focus group

** Participant completed questionnaires as collective (individual NGO members (RSPB and MCS) attended focus group)

*** Participant completed Round 1 questionnaire and attended focus group

†Participant attended focus group only

¹The numbers used to list participants in the above table correspond to those used subsequently in this paper

2.3. Data collection and analysis

The questionnaire responses were imported into QSR International NVivo software (QSR International Pty Ltd, 2010) facilitating organisation, coding and retrieval of the data (Bazeley and Jackson, 2013). Analysis of questionnaire data followed a thematic content analysis to identify salient issues and key elements of the dataset (Green and Thorogood, 2014). Data analysis broadly followed the steps suggested by Braun and Clarke (2006). Each questionnaire was firstly read through in detail with the addition of analytic notes and initial ideas regarding emerging themes. The data was then coded, grouping similar data segments (e.g. a particular sentence) together under each emergent code. Similar codes were combined under key themes that illustrated the perceptions of the participants for each question. All focus group sessions were audio-recorded and field notes were written by the researcher during and after the focus group. Additional field notes collected by the two facilitators, and flip charts produced by the participants were reviewed in the analysis process. The sessions were fully transcribed using NVivo software. Inductive open coding was used to generate codes and categories in the analysis providing a rich, in-depth and grounded account of the data (Corbin and Strauss, 2015). The results were interpreted by relating the categories to the research questions and theoretical ideas underpinning the research.

3. Results

3.1. Management success in the context of climate change

There were conflicting opinions as to whether the conservation objectives set for the MPA sites (conserve or recover for designated features), were ambitious enough in a climate change context. Opposing views were: MPAs should address wider ecological processes, improving the biodiversity of the designated site but also having wider benefits for the marine environment; and MPAs were designated for specific purposes (to conserve or recover specific species and habitats), therefore too high expectations were placed on what the network could successfully achieve.

202 “If the conservation objectives of an individual MPA are achieved then it could be argued
203 that the MPA has been successful but you would maybe want to achieve more in terms of
204 helping to increase resilience in the marine environment to climate change and other
205 pressures.” **Participant 1.**

206 The difference between success of a single MPA site and the success of the network was
207 highlighted, raising the question of how success of the network may be achieved if there are
208 different objectives at a site and network level. Participants felt further work was needed to
209 define ecological coherence and even a working definition of what is considered an MPA
210 network in the context of the Scottish MPA sites.

211 “It is also not clear to what extent the network will be “ecologically coherent” given that it
212 doesn't seem to have been designed with that in mind, but rather to protect a series of key
213 (but at times isolated) features and species.” **Participant 11.**

214 There was concern that the network had not been designed to consider connectivity and
215 therefore that success in terms of realising wider ecosystem health may not be
216 accomplished. Participants recognised that enhancing ecosystem health would be important
217 given the additional stress that climate change would likely have on the marine
218 environment and that the network should not just keep the “status quo” by protecting
219 residual populations. The concept of “status quo” was linked to ideas of dynamism in the
220 marine environment, recognising that features may change in the face of climate change,
221 i.e. it would not be possible to protect MPAs from sea temperature changes, as these wider
222 processes would not recognise the site boundaries. Disagreement was evident; one
223 participant was concerned with the approach recommended to protect areas for wider
224 ecological processes.

225 This view reflects the feature based approach for the network yet appears to contradict
226 with the original Scottish vision for the MPA network. The most widely mentioned factor for
227 success was the ability of the management (as a result of the legislation underpinning the
228 designations recognising climate change) to be adaptable. Participants were divided as to

229 whether planned management and monitoring (at the point of survey) would account for
230 climate change.

231 “The planned management of MPAs in the Scottish MPA network is being driven by the
232 sensitivity of the proposed protected features to pressures arising from activities known to
233 be taking place within the sites. Climate change scenarios really aren't informing
234 management at this stage.” **Participant 1.**

235 Overall, there was a dichotomy in participant opinion for a successful network: the
236 protection of specific features and habitats of conservation interest versus wider
237 improvement of the marine environment as a result of the protection and whether these
238 are mutually achievable.

239

240 3.2. Management scenarios

241 The preceding questionnaires identified management options and discussed the feasibility
242 of these options. These were reframed by the researchers into a matrix of high-level
243 management actions in combination with possible climate change scenarios. For example, a
244 feature is no longer present within the MPA, which possible management option is
245 suitable/acceptable under this scenario. This approach was based on the discussions
246 regarding feasible management options, and recognised the feature-based approach to
247 designation of the Scottish MPAs. The participants were presented with a series of feature-
248 based scenarios whereby the abundance or presence of the feature changed and each
249 scenario was discussed by participants with the aim of deciding which possible management
250 actions were available and under which circumstances these were acceptable and feasible.
251 The matrix focused on the high level options suggested by participants in previous rounds,
252 rather than specific management relating to activities (e.g. types of gear restriction). Sites
253 with multiple designated features present were not considered, however, participants were
254 given the option of considering wider biodiversity and whether this would affect their
255 choice of management action.

The management scenarios matrix (Table 2) summarises the possible management options (from participant discussion) at a site and network level under five different scenarios of change for the MPA feature at the level of an individual MPA: i) the feature is no longer present ii) feature is decreasing iii) feature is stable/demonstrating no overall trend iv) feature is improving and v) the feature is recovered.¹ In terms of the matrix, the above change scenarios are in absolute terms (i.e. not compared to trends in other times and places). The scenarios are also further sub-categorised for site integrity (i.e. wider biodiversity of the site in addition to the status of the feature for which the site is designated) and how the MPA feature is performing at a network level i.e. whether it is stable/declining/increasing across the network. For all scenarios, participants suggested a “balanced review” would be required, and evidence to support decisions before deciding upon any action, taking into account the whole network at appropriate timescales, but did not elaborate on what would constitute a balanced review or what evidence would be needed. Participants suggested that a network review would be useful for a “recalibration”, identifying if any gaps in feature protection were present, or if broader network scale factors (i.e. climate change) were a cause of change. However, it was recognised that identifying causal factors was often incredibly difficult, highlighting the need for a strong monitoring programme. Therefore, some participants maintained a “precautionary” approach to management (i.e. stricter management measures); “precautionary” was also applied in reference to changing management, (i.e. ensuring a strong evidence base before changing current management measures).

Participants felt that a review of management measures would therefore be needed to answer whether the current management had fully removed the pressure. There was also recognition from participants that the dynamic nature of the marine environment would need to be reflected in adaptive management.

Control areas were mentioned in reference to understanding changes and linked to resilience. The option of a new MPA (or moving an MPA) was linked to recovering net loss of

¹ Researchers used the term “recovered” in reference to the draft definitions of MPA conservation objectives of either “conserve” or “recover” (Scottish Government, 2012). At the time of the research there was no quantitative definition or target of “recover” for the individual features.

283 a species where conditions were more favourable, or where suitable climatic conditions still
284 prevailed. A more controversial option (from the participants) was MPA expansion, although
285 mentioned in previous rounds, it was suggested that to expand the area a big change in
286 policy would be needed as the boundaries of a site are tightly drawn around the feature of
287 interest and legislatively implemented.

288 Problems with a feature based approach in a climate change context were identified by the
289 researchers from the participant discussion; a summary of participant discussion and
290 researcher comments around these problems is provided in Table 3.

291

292

MPA feature Scenario at a site level ¹	Site Integrity ²	MPA feature at a network level	Possible Management Actions (from participant discussion)	Decision Making Process (from participant discussion)
No Longer Present	Low quality	Still present	1. New MPA/Move MPA (Look to establish another MPA for the feature) Designate a new alternative area which may succeed, e.g. within new climatic window of feature.	<ul style="list-style-type: none"> - Question whether the current management actions are/were appropriate - Is there an alternative feature within the MPA? - Would maintaining this MPA fill a gap in network wide protection?
	Low/high quality	Still present	2. Reduce pressures in other MPAs. Look at other sites across the network where the PMF is still present within its climate window and reduce other stressors.	
	Low quality	Still present/no longer present across the network	3. De-designate the MPA ³ Option to give up on an area that has failed.	
	High quality site for biodiversity/other features	Still present/no longer present across the network	4. "Rebadge" the MPA (Look to designate the current site for another feature).	
Feature Decreasing	Low/high quality	Stable/Declining	1. Reduce pressures on PMF (further restriction to full ban on damaging activities).	<ul style="list-style-type: none"> - Identify the causes of a decline - Look to recover net loss of the feature across the network
	Low/High quality	Stable/Declining	2. Expand the area of the MPA	
	Low quality	Declining across the network	3. New MPA/Move MPA (Look to establish another MPA for the feature)	
Feature Stable	Low/High quality	Stable	1. Maintain current management measures	- Continue monitoring
Feature Improving	High quality site for feature	Stable across network/Feature common across network	1. Maintain current management measures	<ul style="list-style-type: none"> - Review pressures across the network - Is there clear evidence of improvement? E.g. greater extent, higher biodiversity, better age structure
	High quality for feature	Declining across the network	2. Expand the area of the MPA	
Feature Recovered	High quality for feature	Feature common across network	2. Review management of feature in other sites where it was not present previously	- Need for substantial evidence to reduce or change management

	High quality site for feature, biodiversity and other features	Feature common across network	3. Reduce or change management e.g. is there an option for sustainable use	<ul style="list-style-type: none"> - Is there clear evidence that it was the management of an activity that led to that improvement? - Is there clear evidence of improvement? E.g. greater extent, higher biodiversity, better age structure
--	--	-------------------------------	--	---

294 ¹Change scenarios are in absolute terms (i.e. not compared to trends in other times and places).

295 ²Site Integrity: Quality of the site for wider biodiversity in addition to the status of the feature for which the site is designated. This was summarised as a qualitative
296 statement of either “low quality” or “high quality”. Site integrity was mentioned by participants in reference to site condition monitoring for other nature conservation
297 sites (i.e. SPAs and SACs) and therefore could be of future relevance to the MPA sites, whilst not referenced in MPA objectives.

298 ³De-designate MPA: There is a provision to de-designate an MPA under the Marine Act (Scotland) 2010.

299
300
301
302

Table 3. Summary of participant discussion around problems of a feature based approach in a climate change context

Researcher identified Problem from participant discussion	Participant Comments	Climate change scenario	Researcher Comments
Success judged on a single feature	Success of MPA will be dependent on state of that feature irrespective of wider biological health	Feature declines or is absent from site results in site viewed as failure irrespective of potential wider site improvement.	<i>Conceptually linked to valuation of marine biodiversity. Conflict between feature level objectives, wider pressures and an ecosystem or network level view of success</i>
MPA Management around a particular feature	Feature based management does not account for buffer zones or an ecosystem approach. Damaging activity is not precluded from the entire site, MPA is fragmented into various zones of management. Consequential protection of MPA designation is neglected.	An ecosystem approach required for climate change resilience at a network level is not considered. Wider biodiversity resilience to climate change impacts is not considered. Recovery (range expansion) of species and habitats is unlikely if management is tied to presence.	<i>Conflict between feature level objectives, wider pressures and an ecosystem or network level view of success</i>
"Rebadging" an MPA	A feature, for which the MPA is designated, is lost from the site. Potential for the site to be rebadged/repurposed for another feature.	If a feature is lost and you did not repurpose the MPA, you could lose consequential protection or any improvement in ecosystem health that resulted as a reduction in pressures. Secondly, there may be circumstances where data has improved and led to the identification of other Priority Marine Features (PMFs) or vulnerable species that could benefit from protection. Keep the site for monitoring purposes- resources dedicated	<i>Important that sites be retained for the right reasons which would require a network level review and stakeholder-determined reasons. There was a suggestion that it may be appropriate to look for a new area, although de-designation was seen as a last resort (species may not completely disappear or may have an opportunity to re-establish), but an option that should remain in the "management toolbox". Strong industry concerns in rebadging an MPA due to perceived lack of justification. A logical response from the MPA designation process would be to de-designate an MPA if it has not achieved its management objective (i.e conserve</i>

			<p><i>feature). By retaining the MPA for other reasons than the specific feature designation could be seen as “moving goalposts” by changing the rationale behind designation.</i></p> <p><i>However, there could be a trend towards loss of protection if failing MPAs are removed without seeking to understand why they are failing and seeking to rectify.</i></p> <p><i>Linked to the appropriate allocation of resources</i></p>
Features are not self-recruiting	Sites are not designed using connectivity principles.	Network is not designed as an ecologically coherent one and therefore does not consider potential climate change impacts	<i>Perceived limited consideration of connectivity across the network. Echoes concerns from MPA process stakeholder workshops</i>
Ecosystem health	A species cannot exist in isolation of its ecosystem. Lack of consideration for wider ecosystem health.	Network is not designed as an ecologically coherent one which takes into account wider ecosystem health and therefore does not consider potential climate change impacts	<i>Linked to the lack of connectivity principles across the site.</i>
Precautionary approach	Proposed management* is not optimal (or precautionary) and areas will be under protected. Considering wider ecosystem function and buffer zones of management and concern for whether the selection of features looked at richly biodiverse sites,	To ensure climate change resilience, effective management would be required.	<i>Effective management was considered by some participants as areas of strict protection surrounded by buffer zones</i>
Climate change not considered	Would more MPAs with features that are sensitive to climate change would have been established if climate change had been considered at the beginning of the process. Key features not considered in terms of their vulnerability to climate change	Under scenarios of loss, concerns were raised that if the success or quality of the site is to be judged solely on the status of the feature, and a site were designated for a climate sensitive species (e.g. maerl) which if declined or was lost from the site, the whole site would effectively be redundant. Therefore, it may be possible that a number of sites are potentially vulnerable to the feature being lost; the approach does not account for how assemblages of species in MPA sites may change under climate change scenarios.	<i>Some participants were reluctant to have the MPAs broadened, stating that they should be justified.</i>

		Suggested that sites identified for a specific habitat or biotope are unlikely to lose the whole interest under scenarios of decline. One solution proposed was to widen the designation of the site to incorporate more habitats and features	
--	--	--	--

303 *Proposed Management: At the time of study management measures for the MPA sites were not in place

4. Discussion

Views of MPA success are likely to change under climate change scenarios (Hopkins et al., 2016a); this increases the complexity of applying legal definitions of success, which may become redundant under such scenarios. This study demonstrates the large fragmentation of opinion in what constitutes success even in the absence of considering climate change. As the discussion progressed from questionnaires to the focus group, the agreement of success in abstract principles broke down in the face of operational realities. A fundamental split was evident between participants sympathetic to the provision for sustainable use within the MPA network, and those participants stating that the MPA network should be primarily for conservation, enhancement of the wider marine environment and should contribute to climate change resilience. The different perceptions of MPA success influenced the subsequent discussions of management scenarios; whether participants felt the MPA network should strive for the minimum protection of species and habitats (features) versus MPAs enhancing the wider marine environment.

In the context of the Scottish feature-led MPA process, the approach to management resembles a discriminating approach using a feature sensitivity tool (FEAST),² which analyses the sensitivity of a designated feature to different types of human activity. Management measures based on this sensitivity may not be required across the entirety of the site if the feature is not present across the whole of the site. However, elsewhere there has been a move away from a species-by-species management towards broader ecosystem level strategies (Jentoft et al., 2007). By focusing management measures on one feature or species, impacts on other species (which may be of high ecological importance) are effectively ignored. Better protection of MPA features could be achieved by not only managing the direct impacts (i.e. habitat destruction) but also by considering the wider factors that influence their health (e.g. water quality, prey availability and trophic links). A review of scientific knowledge and international perceptions that informed the development of this study (Hopkins et al., 2016a) suggest management and protection should account for wider ecosystem links and concepts of resilience in the face of a large amount of uncertainty from climate change.

Participants noted that for MPAs to be successful under future scenarios of climate change, flexibility and adaptation were needed. However, although adaptive management is needed for climate change resilient MPAs (Davies et al., 2016; Hopkins et al., 2016a), there are few examples in practice. The importance of monitoring to inform adaptive management was noted whilst discussing

²<http://www.marine.scotland.gov.uk/FEAST/>.

the scenarios to clearly evaluate the effect of protection and to discern the impacts of climate change. Proposed options for adaptively managing MPAs including: flexible boundaries, buffer zones of management, and temporary MPAs that track ecosystem processes or features were deemed far from a practical reality for MPAs at present. The iterative nature of the Delphi method highlighted the difference between proposing options and subsequently using these in a practical scenario. For example, changing MPA boundaries was proposed as an option in the questionnaire rounds, yet when confronted with implementing this option for a range expansion (for example), participants were reluctant to use boundary changes. Changing MPA boundaries was regarded by the environmental sector as too fluid a measure to provide effective long term protection, whilst the fishing sector were concerned that it would lead to long term financial uncertainty. Therefore, whilst most actors within the MPA process advocate adaptive management, it remains difficult to define how this will work in a practical sense.

The success of adaptive management is highly dependent on strong monitoring programmes that are consistent and well-funded (Mee et al., 2008) and the policy context. MPAs are likely to be implemented in the absence of high quality baseline information (Sale et al., 2005) and with a large uncertainty regarding how climate change will affect MPAs. Therefore, as more knowledge becomes available through targeted research and monitoring, adaptive management is a necessary mechanism for incorporating new information and refining management with regards to marine protection (Mee et al., 2008; McDonald and Styles, 2014). Participants highlighted their concerns that the monitoring task for the MPA network was overwhelming, both in terms of the scale of the information needed to be able to confidently state that the network was achieving its aims, and in terms of the amount of resources needed to monitor both at a site and network level. Whilst the political framework is in place for the Scottish network to be adapted in light of new knowledge via the network review process there is also the requirement of political will in order to implement suitable responses (Mee et al., 2008) and robust mechanisms that ensure action is taken in light of new information, rather than a continuation of monitoring.

Participants were concerned that the Scottish MPA network had not been designed to protect ecosystem function and wider biodiversity. MPA networks designed for protecting biodiversity are likely to be important in preserving ecological functioning and therefore contributing to ecosystem resilience (Steneck et al., 2002). A network consisting of strictly protected areas with no intense anthropogenic stressors (e.g. fishing) and that incorporate consideration of ecosystem function are likely to be the most resilient to climate change (Harley et al., 2006; Brock et al., 2012; Micheli et al., 2012). The feature based approach used in Scotland is therefore concerning because without a

367 coherent, connected MPA network, it is unlikely to be resilient to the impacts of climate change
368 (Olds et al., 2012; Magris et al., 2014; Andreello et al., 2015). The approach taken by other countries
369 (e.g. Australia) has been to incorporate multi-use at a network-scale but with a core of strictly
370 protected no-take areas. Single MPAs that are small and not strictly protected, could be considered a
371 false economy as larger well protected MPAs may be less costly in terms of reduced fisheries
372 revenue by increasing the likelihood of spillover, stock recovery and a reduction in the variation of
373 stock levels. However, fishers may not perceive the risk buffering capacity of larger MPAs sufficient
374 to offset the value of foregone harvesting (Carter, 2003). Larger well protected MPAs may be less
375 prone to sudden and unpredictable change (Edgar et al., 2014) and are likely easier to manage,
376 requiring less adaptive management strategies and less detailed long term monitoring. However, at
377 a network scale, there is potential for a portfolio of MPA design, with a range of protection from
378 strict protection/no-take to multiple use. There is a useful opportunity for investigating varying
379 levels of protection across the network, in the recently designated Fair Isle Demonstration and
380 Research MPA as it is specifically targeted toward researching sustainable marine management
381 approaches (FIMETI, 2015).

382 The restoration of marine habitats as outlined in the Marine Strategy Framework Directive (MSFD)
383 and OSPAR guidelines, and a possible site level objective for an MPA feature in the Scottish MPA
384 process recognises the need to increase resilience in degraded ecosystems. Whilst there are strong
385 political foundations for restoration, these do not address the scientific (and socio-political)
386 difficulties (Hopkins et al., 2016b). The use of feature presence is less ambiguous politically when
387 compared to identifying and measuring overall ecosystem health. There are also technical
388 uncertainties over whether a habitat will recover, how long it will take and non-linear recovery
389 trajectories (Mee et al., 2008). Alternative stable states of an ecosystem may exist which make
390 restoration attempts (to restore the ecosystem to the previous desirable state) unfeasible,
391 impractical or too expensive (Hughes et al., 2005; Selkoe et al., 2015). The concept of shifting
392 baselines (see Pauly (1995)) needs to be considered with regards to the desirable state of the
393 ecosystem that the MPA should achieve. Suggestions from participants that qualitative discussions
394 may need to occur to decide what past ecosystems looked like, echoed recommendations by
395 Campbell et al. (2009) that marine restoration will need to explicitly recognise value laden
396 judgements inherent in the decision context (Mee et al., 2008; Campbell et al., 2009). These value-
397 laden judgements also extend into judgements of what future ecosystems will look like under
398 climate change (as suggested in Hopkins et al., 2016a; b); reference states in this context are
399 particularly contentious in marine systems (Mee et al., 2008).

401 Ecosystem Based Management (EBM) may provide a solution by integrating conservation with
402 spatial ecology and ecosystem functioning. EBM focuses on the protection of multiple species,
403 ecosystem processes and societal values, taking into account the wider effects of human use on the
404 environment (Mee et al., 2008; Campbell et al., 2009; Olds et al., 2012). However, the data
405 requirements for this and the current political landscape may mean that EBM approaches are
406 unlikely to be implemented in the short term. The use of EBM as a solution was also not resolved in
407 this study and remained part of the split in perceptions of whether the wider environment should be
408 considered within the MPA designations. If EBM approaches are unfeasible at present, and feature-
409 led approaches are inappropriate for climate change, management decisions need to be taken in
410 light of data from reference sites and baseline for changes without the confounding influence of
411 controllable (at least to some degree) or restrictable human stressors (e.g. fishing, dredging,
412 development etc.). Without reference sites, “expert judgement” and human perceptions of change
413 are used to make management decisions (Mee et al., 2008). As perceptions of quality can shift over
414 each generation (Pauly, 1995) with each generation having its own reference state for what is high
415 or “good” quality, these perceptions of quality may decrease as generally society becomes used to a
416 lower level (Mee et al., 2008). Subjective management decisions are unlikely to be accurate and
417 reference states of quality imply judgements of what is “good” or “bad” about the natural
418 environment (Mee et al., 2008). The development of the MPA network is therefore recommended as
419 a practical solution, but should include the implementation of strictly protected reference sites to
420 allow more objective assessments of ecosystem health to be made (Mee et al., 2008) and
421 importantly to increase resilience for climate change impacted species and habitats across the wider
422 network.

423 5. Conclusions

424 The use of the Delphi method in this study enabled the researchers to include both stakeholders and
425 decision makers to explore climate change adaptation options tailored to the Scottish MPA network.
426 Continued dialogue between stakeholders, decision makers and scientists will be necessary to
427 monitor, review and adaptively manage the MPA network in the context of climate change. The
428 management framework presented here is intended to support the decision making process,
429 recognising that some of the adaptation options may not be feasible or appropriate in a future
430 context, and any decision should be made in response to new information and with consultation.

Over the course of the iterative process, a fundamental split between the perceptions of different stakeholder groups became evident. Those stakeholders, sympathetic to the provision of sustainable use (i.e the fishing sector representative) were supportive of the feature approach to conservation which underpins MPA designation in Scotland. Conversely, other stakeholders felt conservation through MPAs should contribute to wider ecosystem health requiring consideration of ecosystem links in the application of management. The process indicated that this difference in perception may be intractable between the two groups even within a carefully designed MPA process. The Scottish MPA process designated MPAs with an evidence base (feature presence and impact sensitivity) yet also specifies aiming to enhance ecosystem health and contribute to an ecologically coherent network but without a mechanism for Ecosystem Based Management (EBM) or a clear strategic ecosystem level vision. Proposed feasible options for including climate change specific management and monitoring strategies as a result of this study include the use of experimental reference areas (e.g. Fair Isle MPA). These areas could be used to monitor the impact of climate change on MPA species and habitats and the effect of varying levels of protection across the network on climate change resilience. Marine reserves are at this point considered politically unfeasible with some stakeholders, and the use of EBM as a solution appears unresolved.

From a scientific perspective strictly protected marine reserves are thought to be more resilient to climate change and reference areas will be critical to understand climate change impacts and effects supported by monitoring over medium to long-term timescales. Developing scenarios for MPAs under climate change is a useful exercise in developing potential management options and aiding decision making. For the Scottish MPA network, a key recommendation would be to develop research regarding how the MPA network at various scales will be affected by climate change, and use the outputs from this study to guide decisions regarding MPA management.

Acknowledgements

Thank you to all the participants in this study and to Dr Sophie Elliot and Dr Joanne Clark for assistance in facilitation. Thank you to the reviewers of this manuscript for their insights. This research was supported and funded by ClimateXChange (referenceno:A10431853). ClimateXChange is a collaborative initiative between Scottish research and higher education institutes and is funded by the Scottish Government. The participant workshop was supported by a MASTS Small Grant SG215.

References

462 Akins, R.B., Tolson, H., Cole, B.R., 2005. Stability of response characteristics of a Delphi panel :
463 application of bootstrap data expansion. *BMC Med. Res. Meth.* 5.

464 Allison, G.W., Lubchenco, J., Carr, M.H., 1998. Marine reserves are necessary but not sufficient for
465 marine conservation. *Ecol. Appl.* 8, 79–92.

466 Andreello, M., Mouillot, D., Somot, S., Thuiller, W., Manel, S., 2015. Additive effects of climate change
467 on connectivity between marine protected areas and larval supply to fished areas. *Divers. Distrib.* 21,
468 139–150.

469 Bazeley, P., Jackson, K., 2013. *Qualitative Data Analysis with NVivo*, second ed. Sage Publications,
470 London. California. New Delhi. Singapore.

471 Bernhardt, J.R., Leslie, H.M., 2013. Resilience to climate change in coastal marine ecosystems. *Annu.*
472 *Rev. Mar. Sci.* 5, 371–392.

473 Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101.

474 Brock, R.J., Kenchington, E., Martinez-Arroyo, A. (Eds.), 2012. *Scientific Guidelines for Designing*
475 *Resilient Marine Protected Area Networks in a Changing Climate*. Commission for Environmental
476 Cooperation, Montreal. Canada.

477 Campbell, L.M., Gray, N.J., Hazen, E.L., Shackeroff, J.M., 2009. Beyond baselines: rethinking priorities
478 for ocean conservation. *Ecol. Soc.* 14 [www document]. <http://www.ecologyandsociety>.

479 Carter, D.W., 2003. Protected Areas in Marine Resource Management: Another Look at the
480 Economics and Research Issues.

481 Chuenpagdee, R., Pascual-Fernández, J.J., Szeliánszky, E., Luis Alegret, J., Fraga, J., Jentoft, S., 2013.
482 Marine protected areas: Re-thinking their inception. *Mar. Pol.* 39, 234–240.

483 Cliquet, A., Backes, C., Harris, J., Howsam, P., 2009. Adaptation to climate change – legal challenges
484 for protected areas. *Utrecht Law Rev.* 5, 158–175.

485 Corbin, J.M., Strauss, A., 2015. *Basics of Qualitative Research. Techniques and Procedures for*
486 *Developing Grounded Theory*, fourth ed. Sage Publications, UK.

487 Côté, I.M., Darling, E.S., 2010. Rethinking ecosystem resilience in the face of climate change. *PLoS*
488 *Biol.* 8, e1000438.

489 Davies, H.N., Beckley, L.E., Kobryn, H.T., Lombard, A.T., 2016. Features into the incremental
490 refinement of an existing marine park. *PLoS One* 11, 1–21.

491 Edgar, G.J., Stuart-Smith, R.D., Willis, T.J., Kininmonth, S., Baker, S.C., Banks, S., Barrett, N.S.,
492 Becerro, M.A., Bernard, A.T.F., Berkhout, J., Buxton, C.D., Campbell, S.J., Cooper, A.T., Davey, M.,
493 Edgar, S.C., Försterra, G., Galván, D.E., Irigoyen, A.J., Kushner, D.J., Moura, R., Parnell, P.E., Shears,
494 N.T., Soler, G., Strain, E.M.A., Thomson, R.J., 2014. Global conservation outcomes depend on marine
495 protected areas with five key features. *Nature* 506, 216–220.

496 FIMETI, 2015. Fair Isle Proposed Demonstration and Research MPA (Final Document). Available from:
497 <http://www.gov.scot/Resource/0049/00494122.pdf>.

498 Glass, J.H., Scott, A.J., Price, M.F., 2013. The power of the process: Co-producing a sustainability
499 assessment toolkit for upland estate management in Scotland. *Land Use Pol.* 30, 254–265.

500 Gobbi, M., Riservato, E., Bragalanti, N., Lencioni, V., 2012. An expert-based approach to invertebrate
501 conservation: identification of priority areas in central-eastern Alps. *J. Nat. Conserv.* 20, 274–279.

502 Green, J., Thorogood, N., 2014. *Qualitative Methods for Health Research*. Sage Publications, Uk.

503 Harley, C.D.G., Hughes, A.R., Hulgren, K.M., Miner, B.G., Sorte, C.J.B., Thornber, C.S., Rodriguez, L.F.,
504 Tomanek, L., Williams, S.L., 2006. The impacts of climate change in coastal marine systems. *Ecol.*
505 *Lett.* 9, 228–241.

506 Harley, C.D.G., Rogers-Bennett, L., 2004. The potential synergistic effects of climate change and
507 fishing pressure on exploited invertebrates on rocky intertidal shores. *Calif. Coop. Ocean. Fish.*
508 *Investig. Rep.* 45, 98–110.

509 Hess, G.R., King, T.J., 2002. Planning open spaces for wildlife. *Landsc. Urban Plann.* 58, 25–40.

510 Holling, C.S., 1973. Resilience and stability of ecological systems. *Annu. Rev. Ecol. Evol. Syst.* 4, 1–23.

511 Hopkins, C.R., Bailey, D.M., Potts, T., 2016a. Perceptions of practitioners: managing marine
512 protected areas for climate change resilience. *Ocean Coast Manag.* 128, 18–28.

513 Hopkins, C.R., Bailey, D.M., Potts, T., 2016b. Scotland's Marine Protected Area network: reviewing
514 progress towards achieving commitments for marine conservation. *Mar. Pol.* 71, 44–53.

515 Howson, C., Steel, L., Carruthers, M., Gillham, K., 2012. Identification of Priority Marine Features in
516 Scottish Territorial Waters. Scottish Natural Heritage Commissioned Report No. 388.

517 Hsu, C., Sandford, B., 2007. The Delphi technique: making sense of consensus. Practical assessment.
518 *Res. Eval.* 12, 1–8.

519 Hughes, T.P., Bellwood, D.R., Folke, C., Steneck, R.S., Wilson, J., 2005. New paradigms for supporting
520 the resilience of marine ecosystems. *Trends Ecol. Evol.* 20, 380–386.

521 Jentoft, S., van Son, T.C., Bjorkan, M., 2007. Marine protected areas: a governance system analysis.
522 *Hum. Ecol.* 35, 611–622.

523 Krueger, R.A., Casey, M.A., 2009. Focus Groups: a Practical Guide for Applied Research.

524 Lemieux, C.J., Scott, D.J., 2011. Changing climate, challenging choices: identifying and evaluating
525 climate change adaptation options for protected areas management in Ontario, Canada. *Environ.*
526 *Manag.* 48, 675–690.

527 Levy, J., Ban, N., 2013. A method for incorporating climate change modelling into marine
528 conservation planning: an Indo-west Pacific example. *Mar. Pol.* 38, 16–24.

529 Linstone, H.A., Turoff, M., 2002. The Delphi Method: Techniques and Applications. *Page Futures*
530 *Research Methodology*.

531 Lubchenco, J., Palumbi, S., Gaines, S.D., Andelman, S., 2003. Plugging a hole in the ocean: the
532 emerging science of marine reserves 1. *Ecol. Appl.* 13, 3–7.

533 Magris, R.A., Pressey, R.L., Weeks, R., Ban, N.C., 2014. Integrating connectivity and climate change
534 into marine conservation planning. *Biol. Conserv.* 170, 207–221.

535 McDonald, J., Styles, M.C., 2014. Legal strategies for adaptive management under climate change. J.
536 Environ. Law 26, 25–53.

537 Mee, L.D., Jefferson, R.L., Laffoley, D.D.'A., Elliott, M., 2008. How good is good? Human values and
538 Europe's proposed Marine Strategy Directive. Mar. Pollut. Bull. 56, 187–204.

539 Micheli, F., Saenz-Arroyo, A., Greenley, A., 2012. Evidence that marine reserves enhance resilience to
540 climatic impacts. PLoS One 7, e40832.

541 Mukherjee, N., Huge, J., Sutherland, W.J., McNeill, J., Van Opstal, M., Dahdouh-Guebas, F., Koedam,
542 N., 2015. The Delphi technique in ecology and biological conservation: applications and guidelines.
543 Met. Ecol. Evol. <http://dx.doi.org/10.1111/2041-210X>. 12387.

544 O'Neill, S.J., Osborn, T.J., Hulme, M., Lorenzoni, I., Watkinson, A.R., 2008. Using expert knowledge to
545 assess uncertainties in future polar bear populations under climate change. J. Appl. Ecol. 45, 1649–
546 1659.

547 Olds, A.D., Pitt, K.A., Maxwell, P.S., Connolly, R.M., 2012. Synergistic effects of reserves and
548 connectivity on ecological resilience. J. Appl. Ecol. 49, 1195–1203.

549 Pauly, D., 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends Ecol. Evol. 10,
550 430.

551 Pollnac, R., Christie, P., Cinner, J.E., Dalton, T., Daw, T.M., Forrester, G.E., Graham, N.A.J.,
552 McClanahan, T.R., 2010. Marine reserves as linked social-ecological systems. Proc. Natl. Acad. Sci.
553 U.S.A. 107, 18262–18265.

554 QSR International Pty Ltd, 2010. NVivo Qualitative Data Analysis Software, tenth ed.

555 Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review.
556 Biol. Conserv. 141, 2417–2431.

557 Rowe, G., Wright, G., 2011. The Delphi technique: past, present, and future prospects - introduction
558 to the special issue. Technol. Forecast. Soc. Change 78, 1487–1490.

559 Sale, P.F., Cowen, R.K., Danilowicz, B.S., Jones, G.P., Kritzer, J.P., Lindeman, K.C., Planes, S., Polunin,
 560 N.V.C., Russ, G.R., Sadovy, Y.J., Steneck, R.S., 2005. Critical science gaps impede use of no-take
 561 fishery reserves. *Trends Ecol. Evol.* 20, 74–80.

562 Scottish Government, 2011a. A Strategy for Marine Nature Conservation in Scotland's Seas. Available
 563 from:
 564 <http://www.scotland.gov.uk/Topics/marine/marineenvironment/Conservationstrategy/marineconst>
 565 [rategy](http://www.scotland.gov.uk/Topics/marine/marineenvironment/Conservationstrategy/marineconst).

566 Scottish Government, 2011b. Marine Protected Areas in Scotland's Seas: Guidelines on the Selection
 567 of MPAs and the Development of the MPA Network. Available from:
 568 <http://www.scotland.gov.uk/Topics/marine/marineenvironment/mpanetwork/mpaguidelines>.

569 Scottish Government, 2012. Report to the Scottish parliament on progress to identify a Scottish
 570 network of marine protected areas. Available from:
 571 <http://www.scotland.gov.uk/Topics/marine/marine->
 572 [environment/mpanetwork/MPAParliamentReport](http://www.scotland.gov.uk/Topics/marine/marine-environment/mpanetwork/MPAParliamentReport).

573 Selkoe, K.A., Blenckner, T., Caldwell, M.R., Crowder, L.B., Erickson, A.L., Essington, T.L., Estes, J.A.,
 574 Fujita, R., Halpern, B.S., Hunsicker, M.E., Mach, M.E., Martone, R.G., Mease, L.A., Salomon, A.K.,
 575 Samhuri, J.F., Scarborough, C., Stier, A.C., White, C., Zedler, J., 2015. Principles for managing marine
 576 ecosystems prone to tipping points. *Ecosys. Health Sustain.* 1, 17.

577 Steneck, R.S., Graham, M.H., Bourque, B.J., Corbett, D., Erlandson, J.M., Estes, J.A., Tegner, M.J.,
 578 2002. Kelp forest ecosystems: biodiversity, stability, resilience and future. *Environ. Conserv.* 29, 436–
 579 459.